J. Arab. Crops Market. 05 (02) 2023. 49-54 DOI: 10.33687/jacm.005.02.4800

Available Online at EScience Press
Journal of Arable Crops and Marketing
ISSN: 2709-8109 (Online), 2709-8095 (Print)
https://esciencepress.net/journals/JACM

Genetic Diversity Studies in Durum Wheat (*Triticum durum* L.) Accessions

[a]Ghulam Sajjad Kaleri, [a]Shabana Memon, [b]Asif Ali Kaleri, [b]Murad Ali Magsi, [b]Vijai Kumar, [a]Abdul Jabbar Dhiloo, [a]Muzamil Hussain Awan, [b]Ghulam Mustafa Banbhan, [c]Imtiaz Ali Kaleri, [a]Muzamil Hussain Kalhoro, [c]Mohsin Khan Kaleri, [a]Ghazala Soomro, [d]Najeebullah Kakar, [a]Amjad Raza Shar

[a] *Department of Plant Breeding and Genetics, Sindh Agriculture University, Tando Jam, Sindh, Pakistan.*
[b] *Department of Agronomy, Sindh Agriculture University, Tando Jam, Sindh, Pakistan.*
[c] *Department of Biotechnology, Sindh Agriculture University, Tando Jam, Sindh, Pakistan.*
[d] *Balochistan Agriculture College, Quetta, Pakistan.*

**Corresponding Author Email: asifalikaleri2013@gmail.com*

A B S T R A C T

Genetic diversity among durum wheat tetraploid species has a premium to understand the diversity within the genotypes. This study's major objective was to learn more about the diversity and relationships between various durum genotypes. The experiment was design randomized complete block design with three replications. In this study, a total of eight durum advance lines, namely DW-1, DW-2, DW-3, DW-4, DW-5, DW-6, DW-7, and DW-8, were included with one Durum check wheat Miki3 and spring wheat Khirman to investigate the interrelationship and genetic diversity of quantitative traits and they 'reaming these traits. For nearly all of the features, the analysis of variance revealed considerable variations among the durum advance lines, as evidenced by the significant mean squares at a probability level of $P \leq 0.01$. The mean performance results indicated variations in genotype performance DW8 exhibited maximum days to heading, tallest plant height (cm), and shortest peduncle length was measured in durum wheat. DW6 attained shorter plant height was recorded as compared to both check varieties. A notable variation was detected among the genotypes concerning the trait "number of tillers per m^2". The genotype with the highest number of tillers appeared to be spring wheat and the minimum number of tillers was recorded in DW4, respectively. Significantly maximum number of spikelet's, per spike^{-1},biological yield plant^{-1} and protein content % were observed in DW3, amount of grains spike^{-1} were significant in DW6, main spike yield per plant (g) was recorded in DW3. Whereas minimum grains spike^{-1}and minimum spike yield was observed in DW9, respectively. Grain yield plot^{-1} (2.3333 kg) was observed significantly higher in DW6 and minimum Grain yield plot^{-1} (1.6667 kg) in DW10 was observed. Regards correlation, Grain yield plant^{-1} revealed there was a positive and significant correlation with respect to the trait "days to75% headline, days to 75% maturity, grains Spike^{-1}, main spike yield^{-1} and 1000-Grain Weight (g) (r=0.500**, r=0.679**, r=0.316*, r=0.316*, r=0.533** and r=0.308*). Using UPGMA, two members of cluster 1 and cluster 2 were found to have closer relationship with different durum genotypes. However, miki 3 had closer relation with DW-8. The largest positive PCA loadings were observed in grains yield plant^{-1} and 1000 grains weight for the second, third, fourth and fifth PCA group. Hence, DW-8 was nearer relation with miki3, and DW-3, DW-10 and DW-6 considered the best genotypes according to performance.

Keywords: Genetic diversity, genotypes, durum wheat.

INTRODUCTION

Wheat is the predominant winter crop in Pakistan and holds immense agricultural significance. It serves as a staple food and offers higher protein content compared to other cereal crops. Currently, the most important wheat species are hexaploidy and tetraploid durum wheat (*Triticum durum* L.), which differs in their genomic number, food end use quality attribute and grain composition (Shao *et al*., 2006). Durum wheat, classified under the tribe Hordeae within the Poacceae family, is a member of the Poacceae. It is used for making in modern times, various food items such as bread, pasta, cakes, biscuits, and bakery products, and a wide range of confectionery products have become increasingly popular, and the demand of durum wheat varieties is increasing for making bakery products. Farmers often lack awareness about the significance and potential uses of durum wheat in their agricultural practices; therefore, its production in Pakistan is negligible Wheat holds immense significance as a cereal crop on a global scale, both in relations of its production and employment. Wheat plays a vital role in providing essential energy, protein, and dietary fiber in the diets of both humans and animals. It is important to notify that approximately 20% of the total calories consumed worldwide are contributed by wheat. (FAO, 2010). Genetic diversity of durum the potential of wheat to enhance efficiency through breeding underscores its importance in achieving increased food production. By employing modern plant breeding techniques, such as promoting plant uniformity, we can develop wheat plants that are more effective and exhibit enhanced resistance to various stresses. This, in turn, can contribute to improved agricultural productivity and crop resilience (Khodadadi *et al*., 2011). The necessity to make progress in durum wheat varieties by incorporating a wide range of genetic backgrounds and integrating novel variations into the existing gene pool is justified by studies on genetic diversity. Understanding the diversity across multiple traits is valuable for plant breeders in selecting genotypes that exhibit combinations of desired traits. Both morphological characteristics and molecular markers in wheat can serve as valuable tools for breeders to strategically identify and incorporate desirable traits from diverse wheat varieties into future breeding programs (Arora *et al*., 2014). The protein content of wheat flour plays a significant role in determining its processing capabilities into various food products. Mature wheat grains typically contain protein levels ranging from 8% to 20%. Wheat proteins exhibit a high degree of complexity and interact with each other in diverse ways, which makes their characterization challenging. Traditionally, proteins are classified based on their solubility using the sequential Osborne extraction procedure, resulting in the isolation of albumins, globulins, gliadins, and glutenin's. However, a different approach to classification has been suggested, which emphasizes composition and structure instead of solubility. This alternative classification aims to provide a more comprehensive understanding of wheat proteins (Wolde *et al*., 2016). Durum wheat holds significant economic importance as a crop due to its distinct characteristics and end products. The distinctions between common wheat and durum wheat can primarily be ascribed to variances in their gluten protein characteristics. Generally, durum wheat exhibits weaker gluten compared to bread wheat. However, the development of durum cultivars with strong gluten has led to improved cooking quality in pasta products and enhanced bread baking quality. There is a global trend towards increased consumption of durum wheat products. Pasta, bread, and other grain-based foods form a vital category of healthy, balanced, and nutritious dietary options. Therefore, ongoing research focused on increasing the yield, production, and disease resistance of durum wheat remains crucial (Moayedi *et al*., 2010).

MATERIALS AND METHODS

The evaluation of morphological traits in new genotypes of durum wheat was carried out at the Nuclear Institute of Agriculture (NIA) in Tando Jam during the 15 November 2018–19 Rabi season. The study included ten newly developed advanced genotypes of durum wheat that were selected from the National Durum Wheat Trial. Furthermore, a commercial bread wheat type named Khirman from the area was being used as a control. The fertilizer applications were utilized including DAP recommended dose and Urea with one bag of Murate of Potash (MOP). The flood method of irrigation was applied.

The experiment was set up using an RCBD) design with three replications, ensuring statistical robustness. The genotype was sown in four rows, each 4m long. The plot size was kept as 1.2m x 4.5 m = 5.4 m^2. Details of the experiment are as follows:

Genotypes

10 (08 advance durum wheat genotypes: (dw-1, dw-2, dw-3, dw-4, dw-5, dw-6, dw-7dw-8) One Durum check Miki3 and one spring wheat Randomized Complete Block Design with 03 replications Observations to be recorded: Days to 75% heading: The number of days counted from when the crop reached 75% heading, with the appearance of the boot stage. Days to 75% maturity: The number of days recorded when plants exhibited yellow peduncles and reached 75% physiological maturity. Tillers meter^{-2}: The total number of tillers in a square meter area randomly counted at the time of maturity. Only fertile tillers were considered for this trait.

In the experimental field at Nuclear Institute of Agriculture, Tandojam, a study was conducted during the 2018–19 crop year to assess the efficacy of advanced durum wheat lines. Ten genotypes of durum wheat, eight of which were part of the ten genotypes used in the experiment lines (DW1, DW2, DW3, DW4, DW5, DW6, DW7, DW8) and two reference wheat varieties (Checked spring durum and durum wheat Miki3).The study involved collecting multiple observations, including the number of days for various stages of the crop's development (75% heading stage, 75% maturity), plant height (cm), peduncle length (cm), number of tillers plant-1 spike length (cm), spikelet's spike-1, grain spike-1, Biological yield plot-1 (kg), harvest index (%), (%), grain weight plant-1 (g), grain yield plot-1 (kg), 1000 grains weight (g), and protein contents (%). The results obtained for these different traits are presented below:

Statistical Analysis

The recorded data was subjected to statistical analysis using analysis of variance (ANOVA) following the guidelines suggested by Steel and Torrie (1980). Mean values was compared using Duncan's multiple range test (DMRt). Correlation analysis was conducted according to the methods described by Snedecor and Cochran (1980). Cluster analysis will be performed using the word's method with squared Euclidean distance. Principal Component Analysis (PCA) was carried out using the Multivariate Statistical Package (MVSP 3.).

RESULTS

Analysis of Variance

A comparison of fifteen recorded traits among eight advanced durum wheat lines and two check varieties was conducted using an analysis of variance (ANOVA), as shown in Table 1. The results revealed significant differences (at a probability level of $P \leq 0.01$) among the genotypes for most of the traits. These traits include days to heading, days to maturity, plant height (cm), peduncle length (cm), number of tillers plant^{-1}, spike length (cm), spikelet's spike^{-1}, grains spike^{-1}, biological yield plot^{-1} (kg), harvest index (%), grain weight plant^{-1} (g), grain yield plot^{-1} (kg), 1000 grains weight (g), and protein content (%).The analysis of variance indicated significant variation among the durum wheat lines, as reflected in the mean squares. This finding implies that there is a greater opportunity to select potentially superior lines for future breeding purposes. The significant variation observed among the durum lines allows for the identification and selection of promising genotypes with desirable traits for further improvement through breeding programs.

Mean Performance

The result for Days to 75% heading, revealed Genotypes DW2 and DW8 exhibited the longest days to heading (84.00), while DW7 showed the shortest duration (76.33) compared to the check varieties. For this attribute, there was a lot of diversity among the genotypes. Early-headed genotypes may include valuable for selection, as they have a shorter grain filling period, potentially improving grain yield. Days to 75% maturity: DW1 recorded the highest number of days to 75% maturity (135.33a), with DW5 showing the lowest duration (133.00e).Plant height (cm): DW8 had the tallest plant height (108.73a), while DW6 had the shortest (133.00e).Peduncle length (cm): DW3 had the longest peduncle length (44.400 cm), while DW8 had the shortest (39.133cm).Spike length (cm): DW2 had the longest spikes (42.77cm), while DW4 had the shortest (38.77 cm).Spikelet's spike^{-1}: DW3 had the highest number of spikelet's spike^{-1} (20.33), while DW3 had the lowest (38.77). Grains spike^{-1}: DW3 had the highest amount of grains spike^{-1} (65.13), while DW9 had the lowest (53.60). Grains yield plant^{-1} (g): DW3 achieved the greatest grains yield plant^{-1} (65.13), while DW3 had the lowest (52.33). Main spike yield (g): DW3 had the highest main spike yield (3.56), while DW9 had the lowest (2.54). Biological yield plot^{-1} (kg): DW3 had the highest biological yield per plot (5.433), while DW2 had the lowest (4.200). Grains yield plot^{-1} (kg): DW6 had the highest grain yield plot^{-1} (2.333), while DW10 had the lowest (1.666).1000 grains weight (g): DW4 had the highest 1000-grain weight (55.64g), while DW2 had the lowest (45.18g). Harvest index (%): DW5 had the highest harvest index (49.16), while DW10 had the lowest (38.30). Number of tillers m^2: DW10 had the highest number of tillers m^2 (128.67), while DW4 had the lowest (90.3). Protein content (%): DW3 had the highest protein content (14.90), while the minimum was observed in another genotype (12.60).

Table 1. Mean squares from analysis of variance (ANOVA) of various quantitative traits of durum genotypes.

Source of variance	D.F	Days to 75% heading	Days to 75 % maturity	Plant height	Peduncle length	Spike length	Spikelets spike^{-1}	Grains spike^{-1}	Main spikeyield	Biological yield plot^{-1}	Grain yield plot^{-1}	1000-grain weight	Harvest index %	Number of tillers in m^2	Protein %
Replications	2	0.233	6.400	5.542	2.626	0.047	2.428	3.664	0.131	0.004	0.060	4.997	0.032	96.700	0.021
Genotypes	9	88.077**	75.763**	24.175**	5.138**	5.711**	1.435**	62.024**	0.395**	0.416**	0.168**	34.369**	26.712**	632.967**	1.641**
Error	18	1.344	3.474	1.707	0.830	0.138	0.470	0.470	0.134	0.026	0.031	2.695	1.078	84.256	0.021

** = Highly significant (P<0.01), n.s = non-significant.

Table2. Duncan's multiple range test results for the overall comparative mean performance of durum wheat genotypes for many attributes.

Genotypes	Days to 75%heading	Days to 75% maturity	Plant height (cm)	Peduncle length (cm)	Spike length (cm)	Spikelets Spike-1	Grains spike-1	Main spike yield (g)	Biological yield plot-1 (kg)	Grain yield plot-1(kg)	1000-grain weight (g)	Harvest index %	Number of tillers in m2	Protein %
DW1	83abc	135.33a	101.32cd	41.300b	41.90c	19.667abc	63.733ab	3.4133a	5.2667ab	2.1000abc	50.960bc	39.883df	94.33d	14.100c
DW2	84ab	133.33ab	103.40bc	41.467b	42.777a	20.333a	61.933b	3.1767abc	4.200c	1.8333cd	45.187e	40.720cde	103.00d	14.433b
DW3	80de	133.00ab	100.53de	44.400a	42.100b	20.133ab	65.133a	3.5600a	5.4333a	2.2333ab	55.453a	71.710bc	121.67ab	14.900a
DW4	82.66bc	132.67ab	102.00bcd	41.400b	38.777e	18.733cd	57.933c	2.6667bcd	5.0333b	1.9333bc	55.640a	39.420ef	90.3d	14.700a
DW5	79.33e	133.00e	100.60de	41.667b	41.877b	19.200abcd	62.267b	3.2633abc	5.2333ab	2.4000a	52.853ab	49.167a	93.67d	14.300bc
DW6	81.33cd	132.33ab	98.73e	41.067b	40.50d	18.800cd	65.333a	3.3233ab	5.3667a	2.3333a	48.853cd	43.240b	121.33ab	14.367b
DW7	76.33f	131.33b	100.80de	40.733b	39.877d	19.067bcd	62.133b	3.5400a	5.4000a	2.2333ab	51.093bc	42.647b	125.00ab	14.700a
DW8	84.66a	134.67a	103.80bc	39.133c	40.327d	18.467d	52.333d	2.6933cd	5.2667ab	2.1000abc	52.560b	41.507bcd	112.00bc	13.800d
DW9	76.66f	132.67ab	100.00de	42.133b	42.327ab	18.667cd	53.600d	3.3233ab	5.3333a	2.3000a	50.773bc	42.433bc	99.00cd	13.100e
DW10	66.33g	117.67c	108.73a	41.066b	42.750a	18.333d	62.000b	2.5433d	5.4667a	1.6667d	46.827de	38.303f	128.67a	12.600f
Mean	79.433	131.60	101.95	41.437	41.205	19.140	60.640	3.163	5.2000	2.1133	51.020	41.923	108.90	14.100
LSD(0.5%)	1.9890	3.1973	0.2464	0.5636	0.6379	1.1772	1.8478	0.6288	0.2817	0.3024	2.8164	1.7811	15.746	0.2464
CV	1.46	142	1.28	2.20	0.90	3.59	1.78	11.60	3.66	8.34	3.33	2.48	8.43	1.02

DISCUSSION

Durum wheat, a significant tetraploid species cultivated globally, is highly regarded for its use in pasta and semolina production. It is estimated that the yield of durum wheat is approximately 80% higher compared to bread wheat (Abinasa *et al*., 2011). A study was conducted to assess the genetic diversity among durum wheat genotypes, and the findings emphasized its significance in durum wheat breeding. The study concluded that this genetic diversity leads to the development of more efficient varieties that can thrive in various environmental conditions (Yonas *et al*., 2018). An analysis of variance was performed on a dataset consisting of fifteen recorded traits from eight advanced two check kinds and durum wheat lines (as shown in Table 1). The results achieved revealed statistically significant differences in the mean squares of genotypes for almost all the examined traits, with a probability level of $P \leq 0.01$. These qualities include days to heading, days to maturity, plant height (cm), peduncle length (cm), number of tillers plant^{-1}, spike length (cm), spikelet's spike^{-1}, grains spike^{-1}, biological yield plot^{-1} (kg), harvest index (%), grain weight plant^{-1} (g), grain yield plot^{-1} (kg), 1000-grains weight (g), and protein content (%). The analysis of variance means squares indicated that durum lines exhibiting significant variation offer a greater opportunity for selecting potentially superior lines in future breeding programs. These findings align closely with our study's results Bogale *et al*. (2016). Another study also reported significant variations in various agronomic traits among durum wheat genotypes. The harvest index was observed significantly higher in DW5 and minimum in DW10 was observed. Protein has been known as an important component. The maximum protein content was observed in DW3, and the lowest protein content was recorded respectively. The current study revealed significant heritability estimates and substantial genetic advances (as a percentage of the mean) for grain yield and various yield-related traits such as the number of productive tillers square^{-1} meter, plant height, thousand kernel weight, kernels number spike^{-1}, and harvest index. These findings strongly suggest that the heritability of these traits primarily stems from additive genetic effects. Consequently, the results indicate that selection could be highly effective in the initial segregating generations for these traits, allowing for the possibility of enhancing durum wheat grain yield by directly selecting for traits related to grain yield. Similar conclusions have been documented in previous research (Salmi *et al*., 2019). Contrarily, the trait of test weight exhibited high heritability estimates along with relatively lower estimates for genetic advance. These observations suggest that non-additive genetic sources of variation play a significant role in determining the heritability of this trait. Furthermore, the combination of high heritability and high genetic advance for grain yield, harvest index, 1000 grains weight, number of grains spike^{-1}, and spike length suggests that these traits are influenced by additive gene effects Singh *et al*. (2013). High heritability estimates and substantial genetic advances, expressed as a percentage of the mean, have been reported for important traits such as the number of grains spike^{-1}, thousand grain weight, and grain yield ha^{-1}in durum wheat. Additionally, both genotypic and phenotypic coefficients of variation were found to be high for these traits. Consequently, selecting individuals based on these characteristics holds great potential for enhancing durum wheat varieties.

CONCLUSIONS

It is concluded from the present research that the mean squares from analysis of variance revealed that the durum advance lines differed significantly at $P \leq 0.01$ probability level for almost all the traits. The mean performance results suggested that genotype DW8 exhibited maximum days to heading, tallest plant height (cm), and shortest peduncle length was measured in durum wheat respectively. DW6 attained shorter plant height was recorded as compared to both check varieties, respectively.

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